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Annual Water Sampling and Analysis, Calendar Year 2002:

SHOAL Test Site Area
FAULTLESS Test Site Area
RULISON Test Site Area
RIO BLANCO Test Site Area
GASBUGGY Test Site Area
GNOME Test Site Area

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GNOME Test Site Area

by

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ABSTRACT

The U. S. Environmental Protection Agency, Radiation and Indoor Environments National Laboratory in Las Vegas, Nevada (R&IE), operates the radiological surveillance program surrounding the Nevada Test Site (NTS) and, in addition, monitors former nuclear test areas in Alaska, Colorado, Mississippi, Nevada, and New Mexico, each year under the Long Term Hydrological Monitoring Program (LTHMP). The LTHMP is designed to detect residual man-made radionuclides in surface and ground water resulting from underground nuclear test activities. This report describes the sampling and analysis of water samples collected from six former nuclear test sites in three western states during 2002; Projects Shoal and Faultless in Nevada; Projects Rulison and Rio Blanco in Colorado; and Projects Gasbuggy and Gnome in New Mexico. Monitoring results for Alaska and Mississippi are reported separately.

Radiological results for 2002 are consistent with results from previous years. No increase was seen in either tritium concentrations or gamma-ray emitting radionuclides at any site. Tritium levels at the sites are generally decreasing or stable and are well below the 20,000 pCi/L guideline specified in the National Primary Drinking Water Regulations; Radionuclides; Final Rule (40CFR9/141/142), with the exception of samples from several deep wells adjacent to the nuclear cavity at the Gnome site. As in previous years, the highest tritium value recorded for any sample, 3.79×10^7 pCi/L, was from one of these wells, Well DD-1 (Project Gnome).

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ACRONYMS AND ABBREVIATIONS

AEC	U.S. Atomic Energy Commission
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
DCG	Derived Concentration Guide (20,000 pCi/L for Tritium in Drinking Water)
g	gram
$^3H+$	Enriched Tritium
^3H	Tritium
HpGe	high purity germanium gamma detector
IAG	Interagency Agreement
keV	kilo electron volts (one thousand electron volts)
kg	kilogram, 1000 grams
KT	kiloton (one thousand tons TNT equivalent)
LTHMP	Long-Term Hydrological Monitoring Program
L	liter
m	meter
min	minute
MDA	minimum detectable activity
MDC	minimum detectable concentration
MeV	one million electron volts
mL	milliliter (one thousandth of a liter)
MT	megaton (one million tons TNT equivalent)
ORIA	Office of Radiation and Indoor Air
pCi/L	picocuries per liter = 10^{-12} curies per liter = 1/1,000,000,000,000 curies per liter
PHS	U.S. Public Health Service
R&IE	Radiation and Indoor Environments National Laboratory, Las Vegas, NV
SGZ	surface ground zero
USGS	U.S. Geological Survey
ITC	International Technology Corporation

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1.0 INTRODUCTION

Under an Interagency Agreement with the Department of Energy (DOE), the Radiation & Indoor Environments National Laboratory (R&IE), Office of Radiation and Indoor Air (ORIA), EPA, located in Las Vegas, NV, conducts a Long-Term Hydrological Monitoring Program (LTHMP) to measure radioactivity concentrations in water sources near the sites of former underground nuclear explosions. The results of the LTHMP provide assurance that radioactive materials from the tests have not migrated into drinking water supplies. This report presents the results for the samples collected in February, March, May, and June of 2002, around the following test site areas:

- Project SHOAL Test Site, Churchill County, Nevada
- Project FAULTLESS Test Site, Nye County, Nevada
- Project RULISON Test Site, Garfield County, Colorado
- Project RIO BLANCO Test Site, Rio Blanco County, Colorado
- Project GASBUGGY Test Site, Rio Arriba County, New Mexico
- Project GNOME Test Site, Eddy County, New Mexico

2.0 Sample Analysis

Radiochemical laboratory procedures used to analyze the samples collected for this report are summarized in R&IE's SOPs (see Appendix A and B). These include standard methods to identify natural and man-made gamma-emitting radionuclides, tritium, plutonium, strontium, and uranium in water samples. Two types of tritium analyses were performed; conventional and electrolytic enrichment. The enrichment method lowers the MDC from approximately 300 pCi/L to 5 pCi/L. An upper limit of activity of 700 - 800 pCi/L has been established for the tritium enrichment method because sample cross contamination becomes a problem at higher levels.

It has been decided by EPA, that a maximum of 25 percent of all samples collected would be analyzed by the low-level enrichment method. This decision was based on the time required for analysis and an assessment of past results. Under the current sampling and analysis protocol for the site, all samples are initially screened for tritium activity by the conventional method, and selected samples are enriched. At this time, only sampling locations that are in a position to show migration are selected for enrichment.

Sufficient sample is collected from new sampling locations to perform all routine analyses, and a full-suite of other radiochemical determinations including assays for strontium, plutonium, and uranium.

Summary of Analytical Procedures

Type of Analysis	Analytical Equipment	Counting Period (Min)	Analytical Procedures	Size of Sample	Approximate Detection Limit[a]
HpGe Gamma[b]	HpGe detector calibrated at 0.5 keV/ channel (0.04 to 2 MeV range) individual detector. Efficiencies ranging from 15 to 35%.	~150	Radionuclide concentration quantified from gamma spectral data by online computer program.	3.5 L	Varies with radionuclides and detector used, if counted to a MDC of approx. 5 pCi/L for ^{137}Cs.
^{3}H	Automatic liquid scintillation counter	300	Sample prepared by distillation.	30 - 40 mL	300 to 700 pCi/L
^{3}H+ Enrichment	Automatic liquid scintillation counter	300	Sample concentrated by electrolysis following distillation.	250 mL[C]	5 pCi/L

[a] The detection limit is defined as the smallest amount of radioactivity that can be reliably detected, i.e., probability of Type I and Type II error at 5 percent each (DOE 1981).

[b] Gamma spectrometry using a high purity intrinsic germanium (HpGe) detector.

[C] Sample distilled, then concentrated to ~5 mL by electrolysis.

2.1 Sampling at Project SHOAL, Nevada

History

Project SHOAL, a 12-KT nuclear test emplaced at 365 m (1,204 ft), was conducted on October 26, 1963, in a sparsely populated area near Frenchman Station, Nevada, 28 miles southeast of Fallon, Nevada. The test, a part of the Vela Uniform Program, was designed to investigate detection of a nuclear detonation in an active earthquake zone. The working point was in granite and no surface crater was created. The effluent released during drillback was detected onsite only and consisted of 110 curies of ^{131}Xe and ^{133}Xe, and less than 1.0 curie of ^{131}I.

2.1.1 Sample Collection

Samples were collected on February 11-16, 2002. The sampling locations are shown in Figure 1. All of the locations were sampled with the exception of Well H-3. The pump was inoperable. The routine sampling locations included one spring, two windmills, and eleven wells of varying depths. At least one location, Well HS-1, should intercept radioactivity migrating from the test cavity, if it occurs (Chapman and Hokett 1991).

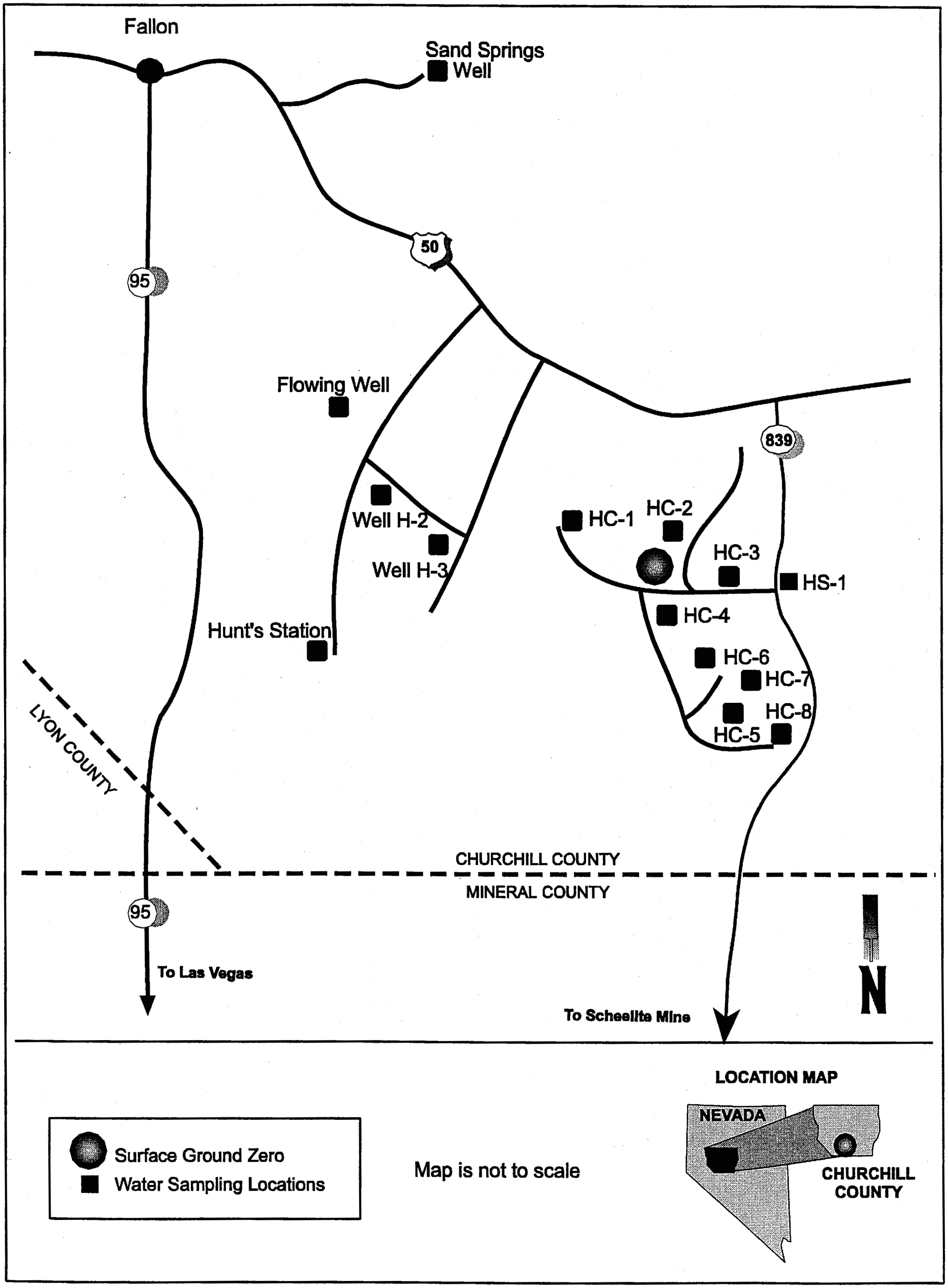

Figure 1. Project SHOAL sampling locations for February 2002.

2.1.2 Water Analysis Results

Gamma-ray spectral analysis results indicated that no man-made gamma-ray emitting radionuclides were present in any samples above the MDC. Tritium concentrations at all locations except for one were below the MDC. The only sampling location that had a tritium concentration above the MDC was Well HC-4 of 259 ± 6.9 pCi/L (see Table 1, below).

2.1.3 Conclusions

No radioactive materials attributable to the SHOAL nuclear test were detected in samples collected in the onsite and offsite areas during 2002.

Analysis Results for Water Samples Collected at the SHOAL Site - February 2002

TABLE 1

Sample Location	Collection Date	Enriched Tritium pCi/L ± 2 SD (MDC)	Tritium(a) pCi/L ± 2 SD (MDC)	Gamma Spectrometry(b) pCi/L (MDC)
Hunts Station	2/12/02		78 ± 129 (210)	ND (4.8)
Flowing Spring Well	2/12/02		-7.2 ± 127 (210)	ND (5.0)
Spring Windmill Well	2/12/02	-3.5 ± 3.7[a] (6.2)		ND (1.5)
Well H-2	2/13/02		9.8 ± 128 (210)	ND (4.8)
Well H-3	2/12/02			Not Sampled
Well HS-1	2/11/02	.	22.5 ± 128 (210)	ND (4.3)
Well HC-1	2/13/02		27 ± 128 (210)	ND (5.0)
Well HC-2	2/13/02	2.3 ± 3.5[a] (5.7)		ND (5.0)
Well HC-3	2/14/02		14 ± 128 (210)	ND (4.6)
Well HC-4	2/16/02	259 ± 6.9 (5.8)		ND (4.7)
Well HC-5	2/15/02	-.96 ± 3.4[a] (5.6)		ND (4.6)
Well HC-6	2/14/02		35 ± 128 (210)	ND (4.4)
Well HC-7	2/15/02		-7.2 ± 127 (210)	ND (4.5)
Well HC-8	2/14/02	-1.4 ± 3.4[a] (5.6)		ND (4.0)

(a) Indicate results are less than MDC (enriched or conventional method).
(b) Value in parenthesis represents ^{137}Cs MDC (pCi/L).
ND Non-detected.

2.2 Sampling at Project FAULTLESS, Nevada

History

Project FAULTLESS was a "calibration test" conducted on January 19, 1968, in a sparsely populated area near Blue Jay Maintenance Station, Nevada. The test had a yield of less than 1 MT and was designed to test the behavior of seismic waves and to determine the usefulness of the site for high-yield tests. The emplacement depth was 975 m (3,200 ft). A surface crater was formed, but as an irregular block along local faults rather than as a saucer-shaped depression. The area is characterized by basin and range topography, with alluvium overlying tuffaceous sediments. The working point of the test was in tuff. The groundwater flow is generally from the highlands to the valley and through the valley to Twin Springs Ranch and Railroad Valley (Chapman and Hokett, 1991).

2.2.1 Sample Collection

Sampling was conducted on March 11-13, 2002. Sampling locations are shown in Figure 2. They include two springs and seven wells of varying depths. All sampling locations were collected with the exception of HTH-2. The pump is inoperable and will be replaced prior to the next sampling in 2003.

At least two wells (HTH-1 and HTH-2) are positioned to intercept migration from the test cavity, should it occur (Chapman and Hokett, 1991). All samples yielded negligible gamma activity. Enriched tritium concentrations except for one were less than the MDC and less than 0.02 percent of the DCG. These results were all consistent with results obtained in previous years. The consistently below-MDC results for tritium indicate that, to date, migration into the sampled wells has not taken place and no event-related radioactivity has entered area drinking water supplies.

2.2.2 Water Analysis Results

All gamma-ray spectral analysis results indicated that no man-made gamma-ray emitting radionuclides were present above MDC. Tritium concentrations at all the locations except for one were below the MDC. The only sampling location that had a tritium concentration above the MDC was a new sampling location at Tybo which was 31 ± 4.0 pCi/L (see Table 2, page 7).

2.2.3 Conclusions

Tritium concentrations in water samples collected onsite and offsite are consistent with those of past studies at the FAULTLESS site. No radioactive materials attributable to the FAULTLESS test were detected in samples collected in the offsite areas. All samples were analyzed for the presence of gamma-ray emitting radionuclides.

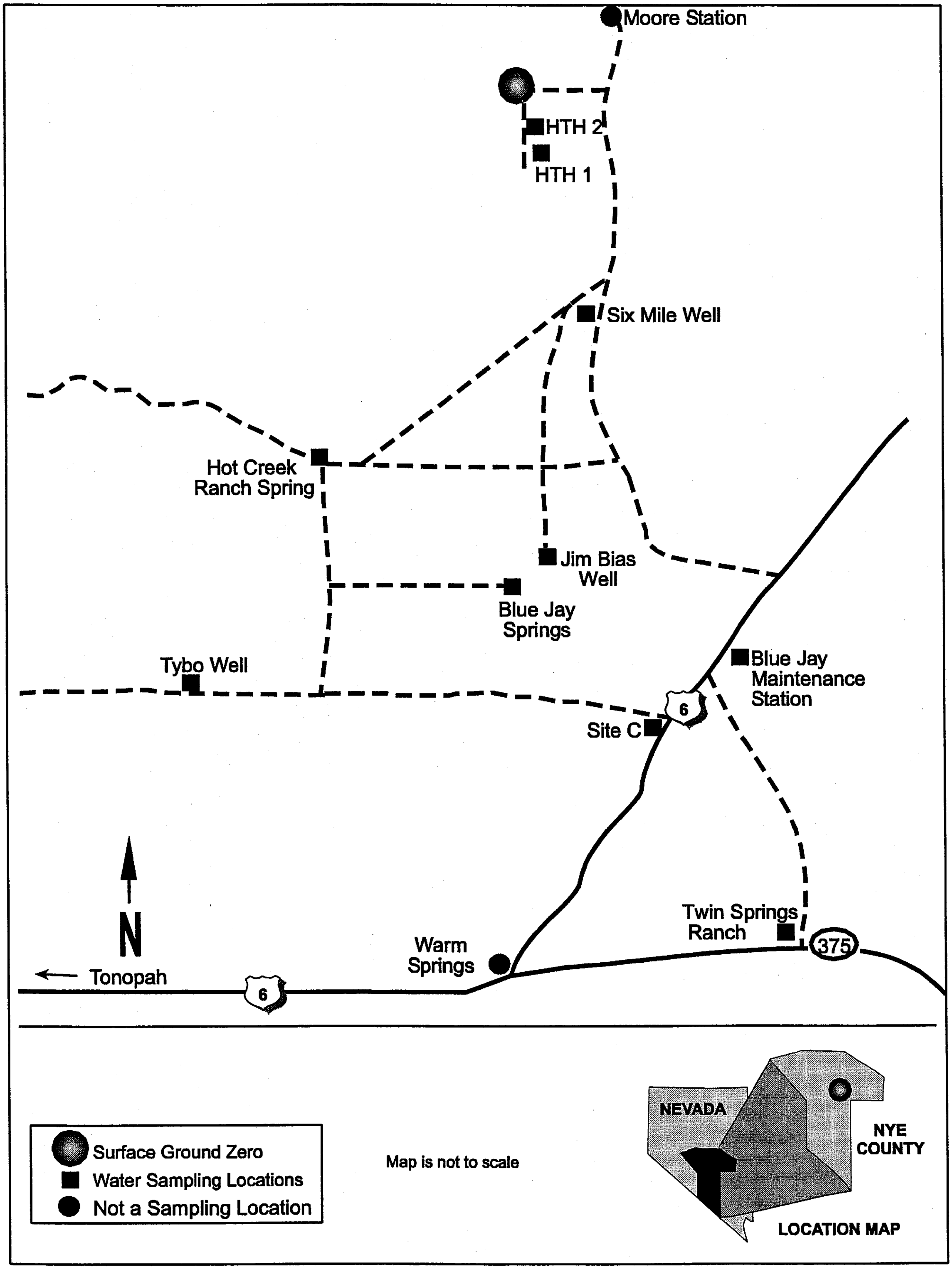

Figure 2. Project FAULTLESS sampling locations for March 2002.

Analysis Results for Water Samples Collected at the FAULTLESS Site - March 2002.

TABLE 2

Sample Location	Collection Date	Enriched Tritium[a] pCi/L ± 2 SD (MDC)	Tritium[a] pCi/L ± 2 SD (MDC)	Gamma Spectrometry[b] pCi/L (MDC)
Hot Creek Ranch	3/12/02		6.3 ± 129 (212)	ND (4.0)
Blue Jay Springs	3/12/02		-19 ± 128 (212)	ND (4.3)
Jim Bias Well	3/12/02			Not Sampled
Blue Jay Maint Station	3/12/02		2.1 ± 129 (212)	ND (5.0)
Well HTH-1	3/13/02	-2.1 ± 3.5[a] (5.8)		ND (4.7)
Well HTH-2	3/12/02			Not Sampled
Site C Base Camp	3/12/02		83 ± 130 (212)	ND (4.8)
Six Mile Well	3/11/02		-.70 ± 127 (212)	ND (5.0)
Tybo Well	3/12/02	31 ± 4.0 (5.7)		ND (1.8)
Twin Springs Ranch	3/11/02	-1.9 ± 4.0[a] (6.7)		ND (4.4)

(a) Indicate results are less than MDC (enriched or conventional method).
(b) Value in parenthesis represents ^{137}Cs MDC (pCi/L).
ND Non-detected.

2.3 Sampling at Project RULISON, Colorado

History

Co-sponsored by the U.S. Atomic Energy Commission (AEC) and Austral Oil Company under the Plowshare Program, Project RULISON was designed to stimulate natural gas recovery in the Mesa Verde formation. The test, conducted near Grand Valley, Colorado, on September 10, 1969, consisted of a 40-KT nuclear explosive emplaced at a depth of 2,568 m (8,425 ft). Production testing began in 1970 and was completed in April 1971. Cleanup was initiated in 1972, and the wells were plugged in 1976. Some surface contamination resulted from decontamination of drilling equipment and fallout from gas flaring. Contaminated soil was removed during the cleanup operations.

2.3.1 Sample Collection

Sampling was conducted on May 15, 2002, from all sampling locations at Grand Valley and Rulison, Colorado. Routine sampling locations are shown in Figure 3. Sampling included the Grand Valley municipal drinking water supply springs, water supply wells for five local ranches, and two sites in the vicinity of surface ground zero (SGZ), including one test well and two surface-discharge springs. The three wells (RU-1, RU-2 and RU-3) located at SGZ, were plugged in 2001, so no sample was taken in 2002.

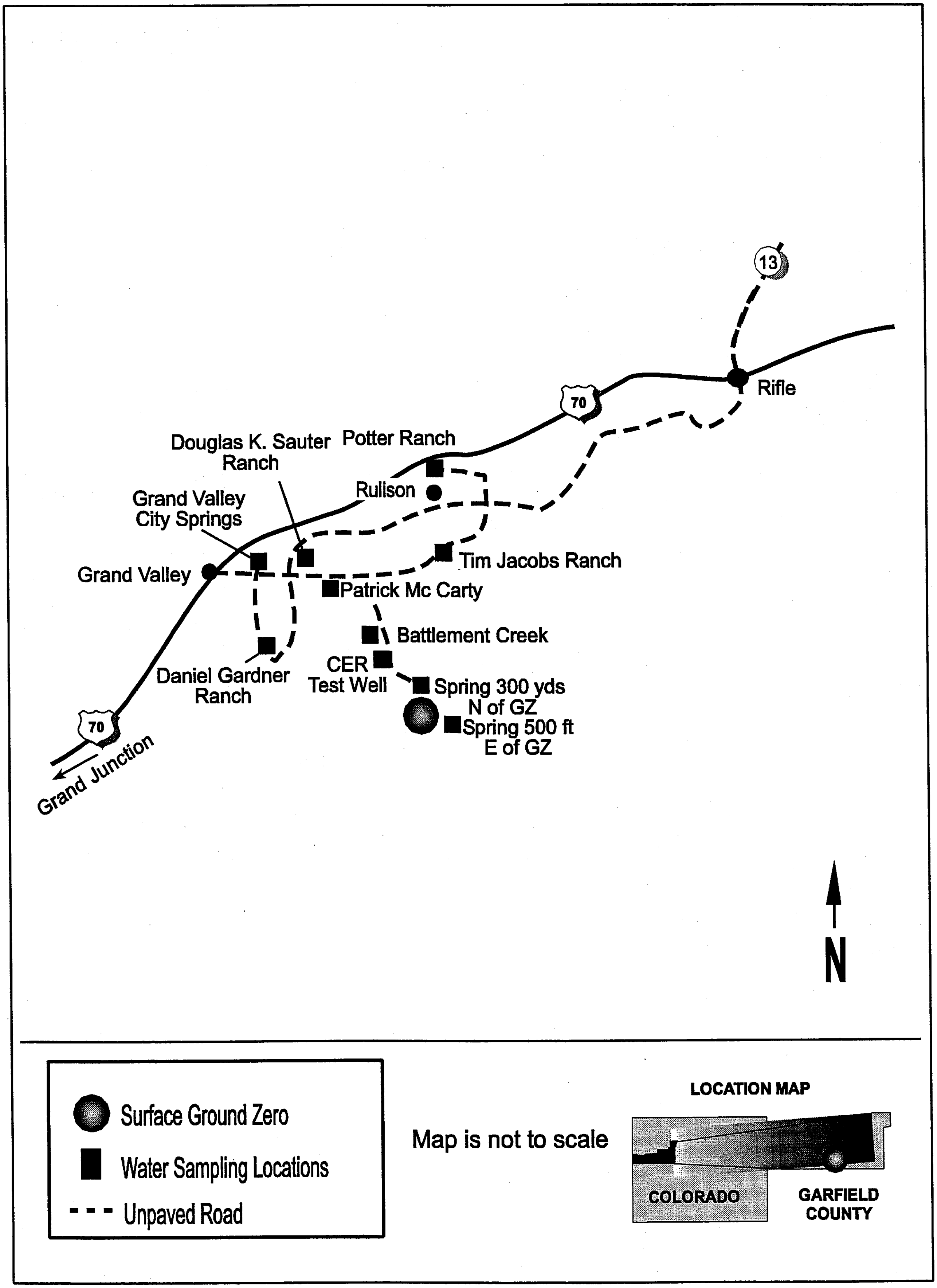

Figure 3. Project RULISON sampling locations for May 2002.

2.3.2 Water Analysis Results

Tritium has never been observed in measurable concentrations in the Grand Valley City Springs. All of the remaining sampling sites show detectable levels of tritium, which have generally exhibited a stable or decreasing trend over the last two decades. The range of tritium activity in 2002, was from 23.5 ± 3.9 pCi/L at the Spring 300 yds N. of GZ to 42 ± 4.8 pCi/L at Potter Ranch (see Table 3). All enriched values were less than 0.25 percent of the DCG (20,000 pCi/L). The detectable tritium activities are consistent with values found in current precipitation and, perhaps, a small residual component remaining from clean-up activities at the site. This is supported by Desert Research Institute analysis, which indicates that most of the sampling locations at the RULISON site are shallow, drawing water from the surficial aquifer, and therefore, unlikely to become contaminated by radionuclide migration from the Project RULISON cavity (Chapman and Hokett 1991).

Analysis Results for Water Samples Collected at the RULISON Site - May 2002

TABLE 3

Sample Location	Collection Date	Enriched Tritium pCi/L ± 2 SD (MDC)	Tritium[a] pCi/L ± 2 SD (MDC)	Gamma Spectrometry[b] pCi/L (MDC)
Battlement Creek	5/15/02		77 ± 138 (225)	ND (5.0)
City Springs	5/15/02		63 ± 137 (225)	ND (4.5)
Daniel Gardner	5/15/02		158 ± 139 (225)	ND (4.9)
CER Test Well	5/15/02		39 ± 137 (225)	ND (4.4)
Patrick McCarty	5/15/02		193 ± 140 (225)	ND (4.7)
Potter Ranch	5/15/02	42 ± 4.8 (6.6)		ND (5.0)
Douglas Sauter	5/15/02	35 ± 4.2 (5.8)		ND (4.6)
Tim Jacobs	5/15/02		53 ± 137 (225)	ND (1.6)
Spring 300 yds N. of GZ	5/15/02	23.5 ± 3.9 (5.7)		ND (4.2)
Spring 500 ft E. of GZ	5/15/02	24 ± 4.5 (6.7)		ND (1.9)
Well RU-1	5/15/02			Well Plugged
Well RU-2	5/15/02			Well Plugged
Well RU-3	5/15/02			Well Plugged

(a) Indicate results are less than MDC (enriched or conventional method).
(b) Value in parenthesis represents ^{137}Cs MDC (pCi/L).
ND Non-detected.

2.3.3 Conclusions

Tritium concentrations in water samples collected onsite and offsite are consistent with those of past studies at the RULISON Test Site. In general, the current level of tritium in shallow wells at the RULISON site cannot be distinguished from the rain-out of naturally produced tritium augmented by, perhaps, a small amount of residual global "fallout tritium" remaining from nuclear testing in the 1950s and 1960s. All routine samples were analyzed for presence of gamma-ray emitting radionuclides.

2.4 Sampling at Project RIO BLANCO, Colorado

History

Project RIO BLANCO a joint government-industry test designed to stimulate natural gas flow was conducted under the Plowshare Program. The test was conducted on May 17, 1973, at a location between Rifle and Meeker Colorado. Three explosives with a total yield of 99 KT were emplaced at 1,780, 1,920, and 2,040 m (5,840, 6,299, and 6,693 ft) depths in the Ft. Union and Mesa Verde formations. Production testing continued until 1976 when cleanup and restoration activities were completed. Tritiated water produced during testing was injected to 1,710 m (5,610 ft) in a nearby gas well.

2.4.1 Sample Collection

Sampling was conducted on May 16-17, 2002, and locations are shown in Figure 4. The routine sampling locations included four springs, four surface, and five wells, three of which are located near the cavity. At least two of the wells (Wells RB-D-01 and RB-D-03) are suitable for monitoring because they were down gradient and would indicate possible migration of radioactivity from the cavity.

2.4.2 Water Analysis Results

Gamma-ray spectral analysis results indicated that no man-made gamma-ray emitting radionuclides were present in any offsite samples. Two of the 15 samples collected were above the MDC for enriched tritium and none were above using the conventional method (see Table 4, page 12).

2.4.3 Conclusions

Tritium concentrations in water samples collected onsite and offsite are consistent with those of past studies at the RIO BLANCO Site. No radioactive materials attributable to the RIO BLANCO test were detected in samples collected in the offsite areas during May 2002. All samples were analyzed for presence of gamma-ray emitting radionuclides.

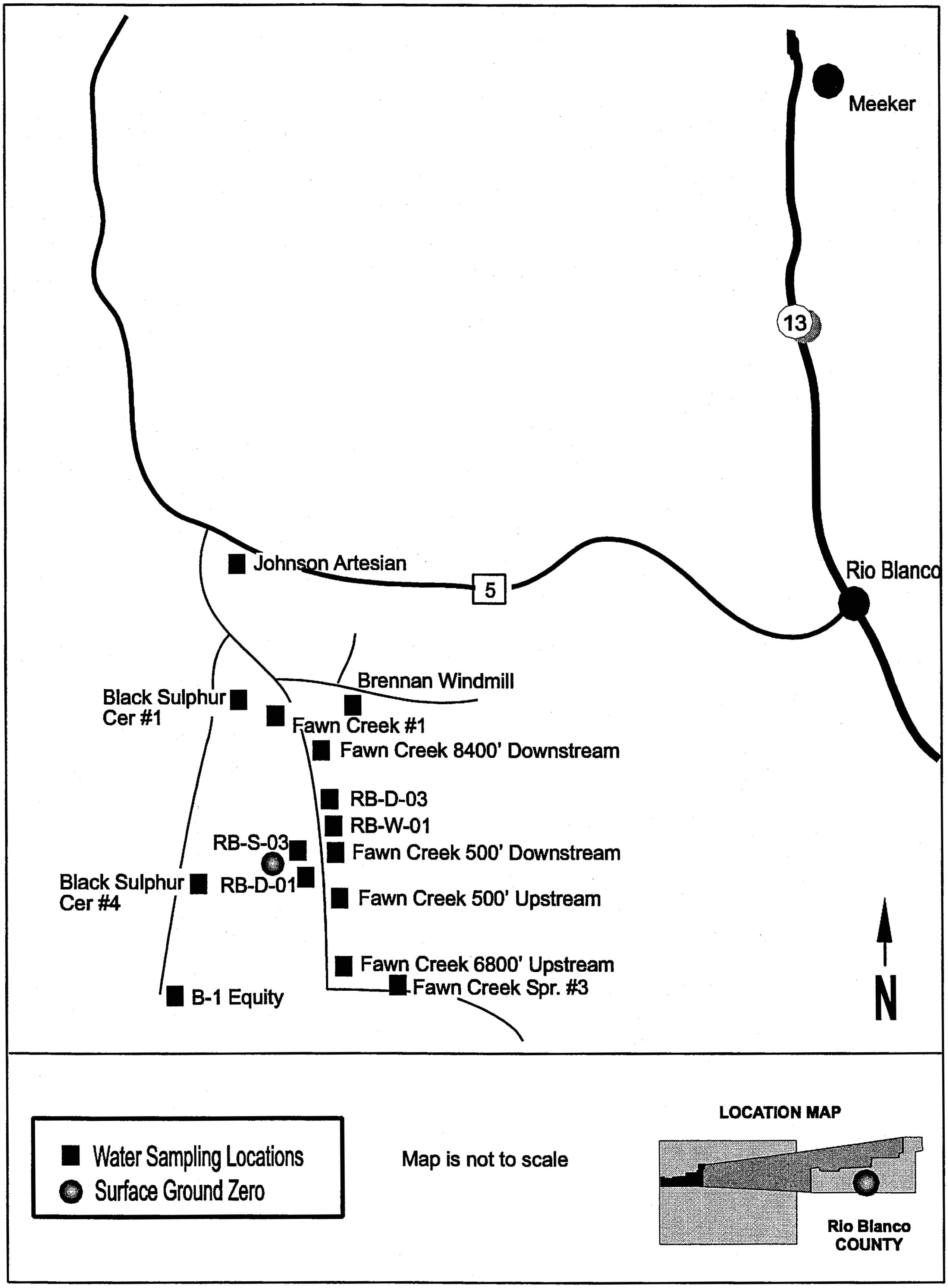

Figure 4. Project RIO BLANCO sampling locations for May 2002.

Analysis Results for Water Samples Collected at the RIO BLANCO Site - May 2002

TABLE 4

Sample Location	Collection Date	Enriched Tritium pCi/L ± 2 SD (MDC)	Tritium[(a)] pCi/L ± 2 SD (MDC)	Gamma Spectrometry[(b)] pCi/L (MDC)
B-1 Equity Camp	5/17/02	25.0 ± 4.0 (5.8)		ND (5.0)
Brennan Windmill	5/16/02		-.14 ± 138 (228)	ND (5.0)
CER #1 Black Sulphur	5/17/02		-50.0 ± 137 (228)	ND (4.9)
CER #4 Black Sulphur	5/17/02		9.0 ± 139 (228)	ND (4.7)
Fawn Creek #1	5/16/02	15.0 ± 4.2 (6.5)		ND (4.9)
Fawn Creek #3	5/17/02		4.5 ± 139 (228)	ND (4.9)
Fawn Creek 500' Upstream	5/17/02		9.0 ± 139 (228)	ND (5.0)
Fawn Creek 6800' Upstream	5/17/02		27.0 ± 139 (228)	ND (4.9)
Fawn Creek 500' Downstream	5/17/02		18.0 ± 139 (228)	ND (4.9)
Fawn Creek 8400' Downstream	5/17/02		77.0 ± 140 (228)	ND (5.0)
Johnson Artesian Well	5/16/02	-.57 ± 3.6[a] (5.9)		ND (4.9)
Well RB-D-01	5/16/02		-27 ± 138 (228)	ND (4.8)
Well RB-D-03	5/16/02	-.26 ± 3.5[a] (5.8)		ND (4.9)
Well RB-S-03	5/16/02		-4.5 ± 138 (228)	ND (4.9)
Well RB-W-01	5/16/02		-81 ± 137 (228)	ND (1.7)

(a) Indicate results are less than MDC (enriched or conventional method).
(b) Value in parenthesis represents ^{137}Cs MDC (pCi/L).
ND Non-detected.

2.5 Sampling at Project GASBUGGY, New Mexico

History

Project GASBUGGY was a Plowshare Program test co-sponsored by the U.S. AEC and El Paso Natural Gas Co., conducted near Gobernador, New Mexico, on December 10, 1967. A nuclear explosive with a 29-KT yield was detonated at a depth of 1,290 m (4,240 ft) to stimulate a low productivity natural gas reservoir. Production testing was completed in 1976 and restoration activities were completed in July 1978.

The principal aquifers near the test site are the Ojo Alamo Sandstone, an aquifer containing non-potable water located above the test cavity, and the San Jose formation and Nacimiento formation.

Both surficial aquifers contain potable water. The flow regime of the San Juan Basin is not well known, although it is likely that the Ojo Alamo Sandstone discharges to the San Juan River 50 miles northwest of the Gasbuggy site. Hydrologic gradients in the vicinity are downward, but upward gas migration is possible (Chapman and Hokett, 1991).

2.5.1 Sample Collection

Annual sampling at Project GASBUGGY was completed during June 19-21, 2002. All of the routine sampling locations were collected except for Bubbling Spring which was dry (see Figure 5).

2.5.2 Water Analysis Results

Tritium concentrations of water samples collected onsite and offsite are consistent with those of past studies at the GASBUGGY Site.

Well EPNG 10-36 has yielded tritium activities between 100 and 560 pCi/L in each year since 1984, except in 1987. The sample collected in June 2002, yielded a tritium activity of 68.0 ± 4.8 pCi/L. The migration mechanism and route are not currently known, although an analysis by Desert Research Institute indicated two feasible routes, one through the Printed Cliffs sandstones, and the other one through the Ojo Alamo sandstone, one of the principal aquifers in the region (Chapman and Hokett, 1991). In either case, fractures extending from the cavity may be the primary or a contributing mechanism. The proximity of the well to the test cavity suggests the possibility that the activity increases may indicate migration from the test cavity.

All gamma-ray spectral analysis results indicated that no man-made gamma-ray emitting radionuclides were present in any onsite and offsite samples above the MDC.

2.5.3 Conclusions

Tritium concentrations of water samples collected onsite and offsite are consistent with those of past studies at the GASBUGGY Site.

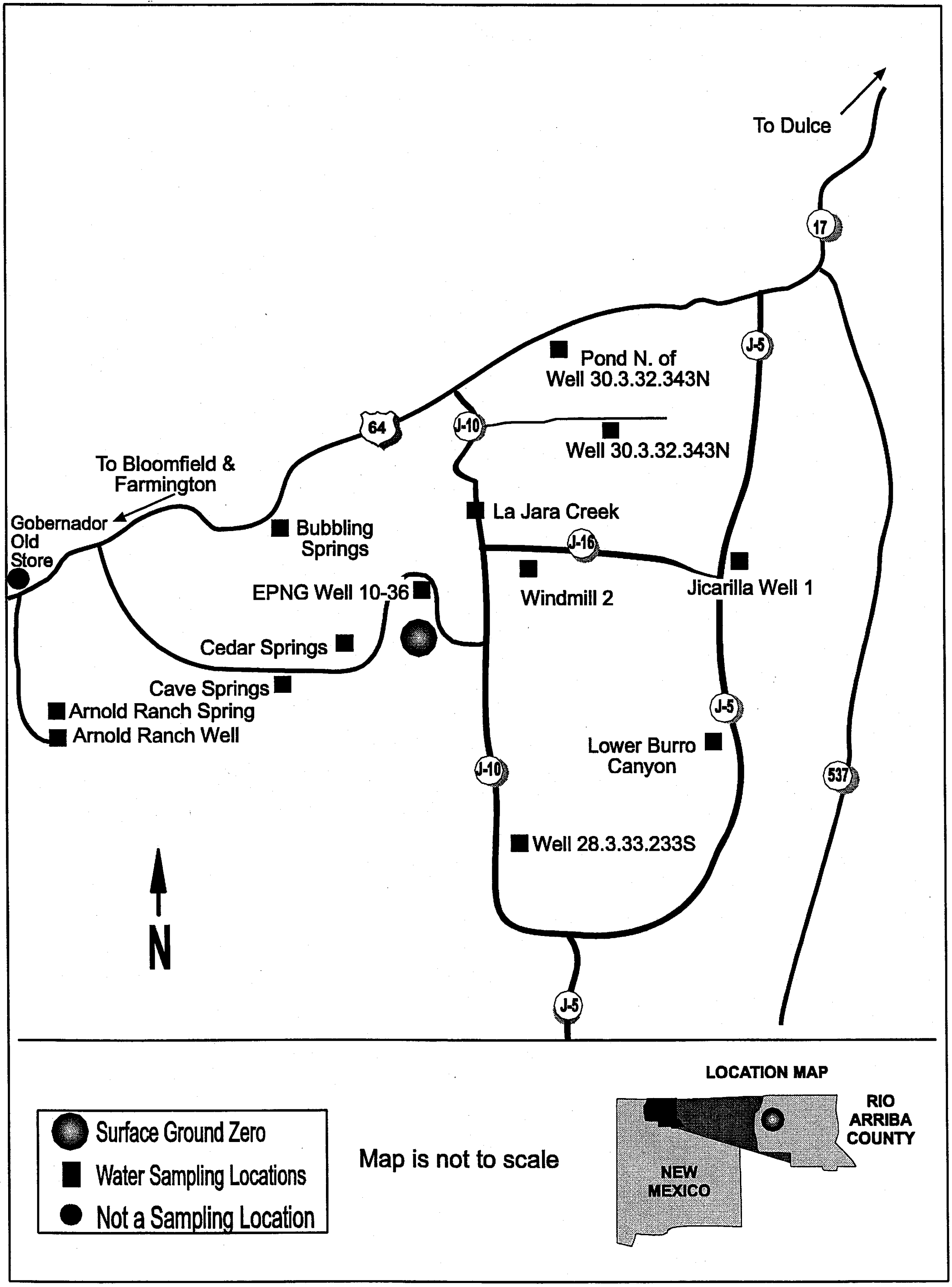

Figure 5. Project GASBUGGY sampling locations for June 2002.

Analysis Results for Water Samples Collected at the GASBUGGY Site - June 2002

TABLE 5

Sample Location	Collection Date	Enriched Tritium pCi/L ± 2 SD (MDC)	Tritium[a] pCi/L ± 2 SD (MDC)	Gamma Spectrometry[b] pCi/L (MDC)
Arnold Ranch Spring	6/21/02		86.0 ± 132 (215)	ND (1.8)
Bubbling Springs	6/21/02			No sample, spring dry
Cave Springs	6/19/02		33.0 ± 131 (215)	ND (4.9)
Cedar Springs	6/20/02		-11.0 ± 130 (215)	ND (4.9)
La Jara Creek	6/19/02	26.0 ± 4.2 (6.2)		ND (4.9)
Lower Burro Canyon	6/19/02		59.6 ± 132 (215)	ND (4.7)
Pond N. of Well 30.3.32.343	6/20/02		86.1 ± 132 (215)	ND (4.9)
Well EPNG-10-36	6/20/02	68.0 ± 4.8 (6.2)		ND (4.9)
Jicarilla Well 1	6/19/02	7.8 ± 3.8 (6.1)		ND (5.0)
Well 28.3.33.233 (South)	6/19/02		2.2 ± 131 (215)	ND (5.0)
Well 30.3.32.343 (North)	6/20/02		126 ± 133 (215)	ND (4.9)
Windmill #2	6/19/02		-11.0 ± 130 (215)	ND (4.8)
Arnold Ranch Well	6/21/02	-.65 ± 3.9[a] (6.4)		ND (4.4)

(a) Indicate results are less than MDC (enriched or conventional method).
(b) Value in parenthesis represents ^{137}Cs MDC (pCi/L).
ND Non-detected.

2.6 Sampling at Project GNOME, New Mexico

History

Project GNOME, conducted on December 10, 1961, near Carlsbad, New Mexico, was a multipurpose test emplaced at a depth of 1,216 ft in the Salado salt formation. The explosive yield was slightly-more-than 3-KT. Oil and gas are produced from the geologic units below the working point. The overlying Rustler formation contains three water-bearing zones: brine located at the boundary of the Rustler and Salado formations, the Culebra Dolomite which is used for domestic and stock supplies, and the Magenta Dolomite which is above the zone of saturation (Chapman and Hokett, 1991). The ground water flow is generally to the west and southwest.

Radioactive gases were accidentally vented following the test. In 1963, USGS conducted a tracer study involving injection of 20 Ci tritium, 10 Ci ^{137}Cs, 10 Ci ^{90}Sr, and 4 Ci ^{131}I in the Culebra Dolomite zone; using Wells USGS 4 and 8. During remediation activities in 1968-69, contaminated material was placed in the test cavity and the shaft up to within 7 ft of the surface. More material was slurried into the cavity and drifts in 1979. A potential exists for discharge of this slurry to the Culebra Dolomite and to Rustler-Salado brine. Potentially this may increase as the salt around the cavity compresses, forcing contamination upward and distorting and cracking the concrete stem and grout.

2.6.1 Sample Collection

Annual sampling at Project GNOME was completed during June 25-27, 2002. The routine sampling sites, depicted in Figure 6, includes ten monitoring wells in the vicinity of surface GZ; the municipal supplies at Loving and Carlsbad, New Mexico.

2.6.2 Water Analysis Results

No tritium activity was detected in the Carlsbad municipal supply or the Loving Station well. An analysis by Desert Research Institute (Chapman and Hokett, 1991) indicates that these sampling locations, which are on the opposite side of the Pecos River from the Project GNOME site, are not connected hydrologically to the site and, therefore, cannot become contaminated by Project GNOME radionuclides.

Tritium results greater than the MDC were detected in water samples from four of the 12 sampling locations in the immediate vicinity of GZ. Tritium activities in wells DD-1, LRL-7, USGS-4, and USGS-8 ranged from 2.36×10^3 (LRL-7) to 3.79×10^7 (DD-1) pCi/L. Well DD-1 collects water from the test cavity; Well LRL-7 collects water from a side drift; and Wells USGS-4 and USGS-8 were used in the radionuclide tracer study conducted by the USGS. None of these wells are sources of potable water.

In addition to tritium, ^{137}Cs and ^{90}Sr concentrations were observed in samples from Wells DD-1, LRL-7, and USGS-8, while ^{90}Sr activity was detected in Well USGS-4 as in previous years (see Table 6). No tritium was detected in the remaining sampling locations, including Well USGS-1, which the DRI analysis (Chapman and Hokett, 1991) indicated is positioned to detect any migration of radioactivity from the cavity. All other tritium results were below the MDC.

2.6.3 Conclusion

No radioactive materials attributable to the GNOME Test were detected in samples collected in the offsite areas during June of 2002.

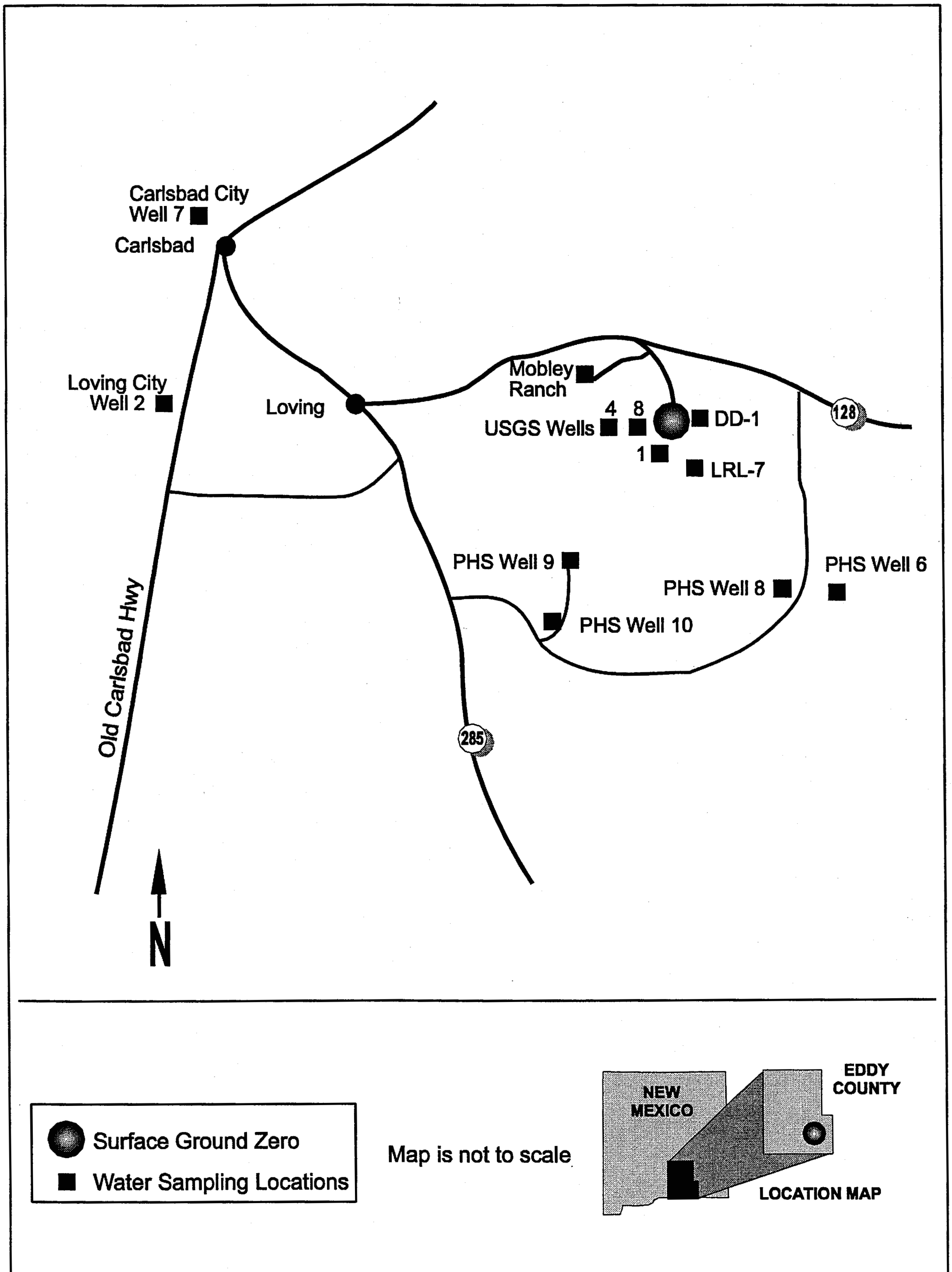

Figure 6. Program GNOME sampling locations for June 2002.

Analysis Results for Water Samples Collected at the GNOME Site - June 2002

TABLE 6

Sample Location	Collection Date	Enriched Tritium pCi/L ± 2 SD (MDC)	Tritium pCi/L ± 2 SD (MDC)	Gamma Spectrometry[b] pCi/L (MDC)
Well 7 City	6/25/02	-.33 ± 4.0[a] (6.7)		ND (4.0)
Well 2 City	6/25/02		19.0 ± 149[a] (244)	ND (5.0)
PHS 6	6/25/02		-84.0 ± 147[a] (244)	ND (4.9)
PHS 8	6/25/02		-36.8 ± 147[a] (244)	ND (5.0)
PHS 9	6/25/02		50.0 ± 149[a] (244)	ND (1.7)
PHS 10	6/25/02		-50.0 ± 147[a] (244)	ND (1.5)
USGS Well 1	6/26/02	-1.3 ± 4.2[a] (7.0)		ND (4.5)
USGS Well 4	6/26/02		$4.86 \times 10^4 \pm 550$ (244)	ND (1.6)
Well USGS 8	6/26/02		$4.57 \times 10^4 \pm 535$ (244)	Cs-137 97.0 ± 15.6 (1.6)
J. Mobley Ranch	6/25/02	1.9 ± 3.7[a] (6.0)		ND (4.9)
Well DD-1	6/27/02		$3.79 \times 10^7 \pm 1.48 \times 10^4$ (244)	Cs-137 $6.45 \times 10^5 \pm 9.73 \times 10^4$ (4.04×10^3)
LRL-7	6/26/02		$2.36 \times 10^3 \pm 189$ (244)	Cs-137 73.0 ± 12.0 (1.9)

(a) Indicate results are less than MDC (enriched or conventional method).
(b) Value in parenthesis represents ^{137}Cs MDC (pCi/L).
ND Non-detected.

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GLOSSARY OF TERMS

Background Radiation

The radiation in man's environment, including cosmic rays and radiation from naturally-occurring and man-made radioactive elements, both outside and inside the bodies of humans and animals. The usually quoted average individual exposure from background radiation is 125 millirem per year in mid-latitudes at sea level.

Curie (Ci)

The basic unit used to describe the rate of radioactive disintegration. The curie is equal to 37 billion disintegrations per second, which is the equivalent of 1 gram of radium. Named for Marie and Pierre Curie who discovered radium in 1898. One microcurie (μCi) is 0.000001 Ci.

Isotope

Atoms of the same element with different numbers of neutrons in the nuclei. Thus ^{12}C, ^{13}C, and ^{14}C are isotopes of the element carbon, the numbers denoting the approximate atomic weights. Isotopes have very nearly the same chemical properties, but have different physical properties (for example ^{12}C and ^{13}C are stable, ^{14}C is radioactive).

Enrichment Method

A method of electrolytic concentration that increases the sensitivity of the analysis of tritium in water. This method is used for selected samples if the tritium concentration is less than 700 pCi/L.

Minimum Detectable Concentration (MDC)

The smallest amount of radioactivity that can be reliably detected with a probability of Type I and Type II errors at 5 percent each (DOE 1981).

Offsite

Areas exclusive of the immediate Test Site Area.

Type I Error

The statistical error of accepting the presence of radioactivity when none is present. Sometimes called alpha error.

Type II Error

The statistical error of failing to recognize the presence of radioactivity when it is present. Sometimes called beta error.

Appendix A

Typical MDA Values for Gamma Spectroscopy
(100 minute count time)

Geometry*	Marinelli	Model	430G
Matrix	Water	Density	1.0 g/ml
Volume	3.5 liter	Units	pCi/L
Isotope	MDA	Isotope	MDA
		Ru-106	4.76E+01
Be-7	4.56E+01	Sn-113	8.32E+00
K-40	4.92E+01	Sb-125	1.65E+01
Cr-51	5.88E+01	I-131	8.28E+00
Mn-54	4.55E+01	Ba-133	9.16E+00
Co-57	9.65E+00	Cs-134	6.12E+00
Co-58	4.71E+00	Cs-137	6.43E+00
Fe-59	1.07E+01	Ce-144	7.59E+01
Co-60	5.38E+00	Eu-152	2.86E+01
Zn-65	1.24E+01	Ra-226	1.58E+01
Nb-95	5.64E+00	U-235	1.01E+02
Zr-95	9.06E+00	Am-241	6.60E+01

Disclaimer
The MDA's provided are for background matrix samples presumed to contain no known analytes and no decay time. All MDA's provided here are for one specific *Germanium detector and the geometry of interest. The MDA's in no way should be used as a source of reference for determing MDA's for any other type of detector. All gamma spectroscopy MDA's will vary with different types of shielding, geometries, counting times and decay time of sample.

Appendix B

Standard Operating Procedures for the Center for Radioanalysis & Quality Assurance

RQA-302	Standard Operating Procedures of Gamma-Ray Detector Systems
RQA-602	Tritium Enrichment Procedure
RQA-603	Standard Operating Procedure for ^{89}Sr and ^{90}Sr in Water, Air Filters and Milk
RQA-604	Standard Operating Procedure of Convention Tritium in Water
RQA-606	Analysis of Plutonium, Uranium and Thorium in Environmental Samples by Alpha Spectroscopy

Standard Operating Procedures for the Center for Environmental Restoration, Monitoring & Emergency Response

CER-203	Standard Operating Procedure for the Long-Term Hydrological Monitoring Program